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Effectiveness of a MP-blocking Splint and Therapy in Rheumatoid Arthritis: A Descriptive Pilot Study

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Rheumatoid arthritis (RA) is a chronic inflammatory, systemic disease affecting the musculoskeletal system. This disease has an unpredictable course with an unpredictable pattern and speed of deterioration.^{1–4} It has a predilection for finger and wrist joints. About 90% of patients with RA have problems in these joints affecting range of motion (ROM), strength, manipulative skills, and reduced possibilities of the hands in daily activities.^{5,6}

In the normal hand, there is a fine balance between the muscle and tendon system and the bone and joint structure. RA disturbs this vulnerable balance. In RA, the inflammatory synovium can result in capsular distension, destruction of cartilage, subchondral erosions, loosening of the ligamentous insertions, impairment of the function of tendons, and finally, joint disorganization.⁷

One of the problems in the rheumatic hand is the intrinsic-plus posture of the fingers⁸ (see [Figure 1](#)). Patients only flex their fingers at the metacarpal

ABSTRACT: The purpose was to evaluate the effect of a metacarpal phalangeal joint blocking splint combined with exercises, aimed at regaining strength, manipulative skills, and a normal pattern of movement of the hands in patients with rheumatoid arthritis (RA). All patients were measured three times: before the start of the therapy, after finishing the therapy, and at three months follow-up. Outcome measures were grip strength, pinch strength (Jamar dynamometer and pinchmeter), active range of motion (goniometer), dexterity (Sequential Occupational Dexterity Assessment [SODA]), and experienced functioning in daily life (Michigan Hand Outcome Questionnaire and Disability of Arm, Shoulder, and Hand questionnaire). The hands treated improved significantly on both total SODA score and on the pain score of the SODA. This means that the dexterity improved over time. No significant changes were found on the other outcome measures. This study indicates that intervention on the function of the hands in patients with RA who present an intrinsic-plus posture and movement pattern, improve significantly on dexterity and pain, measured by the SODA.

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phalangeal (MP) joints, while the interphalangeal (IP) joints are extended. The clinical experience of the hand therapists in our hospital was that patients with an intrinsic-plus posture and abnormal pattern of movement experienced several problems in the use of the hands in daily life. For instance in picking up money, holding a glass, or turning a page of a book.

Several mechanisms, often a combination of biomechanical changes, can lead to this intrinsic-plus posture and pattern of movement over time:

- Stretching or destruction of the capsules and ligamentous insertions around the MP joints can lead to volar (sub) luxation. In this way, the intrinsic muscles (Mm. lumbricales, Mm. interossei dorsales and palmares) can dominate over the extrinsic muscles (M. flexor digitorum superficialis, M. flexor digitorum profundus, M. extensor digitorum communis (EDC), M. extensor indices, M. extensor digiti minimi).
- Synovitis in the intrinsic or extrinsic flexors can diminish the flexion possibilities in the IP joints.
- Synovitis in the extrinsic extensors can diminish the extension possibilities in the MP joints. As a result, the patient only flexes the fingers in the MP joints, while the IP joints are extended.

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FIGURE 1. *Intrinsic-plus posture while holding a glass.*

- If hands are painful, patients tend to move their fingers cautiously with little flexion. Because of the limited ROM of the IP joints, the central and terminal slip and the lateral bands of the extensor hood tend to shorten over time. These changes may lead to the intrinsic-plus posture and abnormal pattern of movement.^{7,9,10}

Based on experience and information on biomechanics of the hand, treatment was developed consisting of a MP-blocking splint in combination with exercises (see Figure 2). The MP-blocking splint was designed to inhibit the activity of the intrinsic muscles and to facilitate the activity of the extrinsic muscles. The exercise program included exercises for combined maximal active flexion and extension of the IP joints and active radial deviation of the fingers. To incorporate the normal pattern of movement,



FIGURE 2. *The MP-blocking splint volar.*

the splint was also worn during daily activities. The objective of this therapy was to improve functional abilities.^{7,9–12}

This splint therapy proved to be very promising in clinical practice. However, scientific evidence to confirm this perception was lacking so far.

The aim of this study was to evaluate the effects of the MP-blocking splint combined with an exercise program in RA patients with the intrinsic-plus posture and pattern of movement of the hand.

MATERIALS AND METHODS

Study Design

This study is a descriptive pilot study with a pretest/posttest design.

Patients

Patients were referred by the rheumatologists from our hospital. Inclusion criteria were 1) diagnosed RA according to the American Rheumatism Association criteria,¹³ 2) no red, swollen, or painful MP or IP joints, 3) intrinsic-plus posture and movement pattern in one hand or both hands observed by picking up a glass and a paperclip from the table with straight fingers, and 4) able to speak and understand the Dutch language. Exclusion criteria were 1) fixed contractures of MP or IP joints, 2) tendon ruptures, EDC slippage, or sagittal band attenuation, and 3) cognitive or psychological problems that could influence the study.

Convenience sampling was used; all individuals fulfilling inclusion criteria entered the study until the desired sample size was reached.

Sample Size

The Michigan Hand Outcome Questionnaire (MHQ) was the primary outcome measure and was used for the sample size calculation ($\alpha = 5\%$, $\beta = 80\%$). Because no publications were found at the time in which the standard deviation of improvements on the MHQ in patients with RA was described, the researchers contacted the developers of the MHQ. They provided unpublished data of ten patients with RA who had filled out the MHQ during a pretest–posttest design study. The standard deviation of the change was 15.3. A clinical relevant difference was set at ten points improvement on the MHQ. These data resulted in a sample size of 23 patients.

Treatment

All patients participating in the study followed splint therapy combined with an standardized exercise program. The MP-blocking splints were manufactured by two occupational therapists; respectively,

with six and nine years of experience in hand therapy. In addition, the exercise program was performed by these two occupational therapists. Patients received instructions verbally and in writing. The therapists evaluated the splint and exercises every one or two weeks for three months, when patients visited the outpatients' clinic.

The MP-blocking splint was designed to inhibit the activity of the intrinsic muscles and to facilitate the activity of the extrinsic muscles. The MP-blocking splint allows undisturbed movement of the wrist (elastic wristband) and IP joints. Because the tendency of the MP joints is to sublux volarly, these joints are held close to full extension (between 10 and 25 degrees of flexion) to provide volar support for the joints and surrounding soft tissues. To stabilize the MP joints in this position, an elastic band with foam was used on the dorsal side of the MP arch (Figure 3).

The exercise program was performed three times a day while wearing the MP-blocking splint. The program included exercises for combined maximal active flexion and active extension of the IP joints, and active radial deviation of the fingers. After each active flexion and active extension, the hand was relaxed in neutral position. The exercises were repeated ten times, 5 seconds in either direction. Patients were instructed verbally and in writing according to the protocol.

Three times a day, the MP-blocking splint was worn approximately 30 minutes during daily activities like doing the dishes, folding up the laundry, preparing breakfast, and personal care. The intention

was to inhibit the intrinsic pattern of movement of the hand and to stimulate moving normally.

Evaluation

Patients were evaluated at baseline (before the start of the treatment, T0), after three months of treatment (T1), and the majority was evaluated three months after ending the therapy, six months after baseline measurement (T2). The researcher (SAF), who was not involved in the treatment of the patients, performed all evaluations.

The evaluations were performed without wearing the splint. Because of the multidimensional impact of RA, the following outcome measures were used.

Grip Strength and Pinch Strength

The grip strength and pinch strength of both hands were measured using the Jamar dynamometer and the pinch meter (lateral pinch, two-point pinch, three-point pinch) as advocated by the American Society of Hand Therapists. The Jamar dynamometer has proven to be a valid and reliable instrument.^{14,15} The pinch meter is also valid and reliable.¹⁶

Range of Motion

The active ROM of all finger joints was measured using a goniometer as described by the American Academy of Orthopedic Surgeons.¹⁷ Subsequently, the data about joint mobility were processed by both systems proposed by "The Committee on Tendon Injuries" based on total active ROM of the MP and IP joints¹⁸ and the first Strickland method.¹⁹ Both methods are commonly used in computing joint mobility. The system by the Committee of Tendon Injuries uses the uninvolved contralateral finger of the patient as a standard. However, in RA an uninvolved contralateral finger is generally unavailable. The first Strickland method computes the total active ROM of the IP joints per finger. This method uses a standard of 175 degrees active ROM for IP joints.

Dexterity

The Sequential Occupational Dexterity Assessment (SODA) measures the dexterity and bimanual use of the hands and includes standardized tasks that are performed by the patient while the clinician assesses the patient's dexterity.²⁰ The SODA is a valid and reliable measurement for assessing disability in RA patients in a clinical situation. The SODA allows separate evaluation of each hand during bilateral tasks, but does not specify the role each hand plays in the task.²¹ The total score ranges from 0 (unable to perform any of the tasks) to 108 (able to perform all tasks as requested). The SODA pain score is assessed by counting the number of tasks causing pain (range 0–12).²⁰



FIGURE 3. The MP-blocking splint dorsal.

The Disability of the Arm, Shoulder, and Hand (DASH) questionnaire is a self-administered questionnaire with high validity, reliability, and sensitivity to change in a rheumatoid population. The DASH is designed to describe the disability experience by people with upper-limb disorders, and monitor changes in symptoms and functions over time. The DASH consists of a 30-item disability/symptom scale, scores range from 0 (no disability) to 100 (very severe disablement).^{22–25}

Patients' Perception of Specific Hand Problems Associated with RA

The MHQ is a hand-specific outcome instrument that includes six distinct scales enabling the patient to describe specific hand problems: overall hand function, activities of daily living, pain, work performance, aesthetics, and patient satisfaction with hand function. It also contains demographic and work history questions. The MHQ is valid and reliable to assess hand disablement in RA patients.²¹ The raw scale score for each of the six scales is the sum of the responses of each scale item. The raw score is converted to a score ranging from 0 to 100. Higher scores indicate better hand performance.^{26–28} This instrument allows computing a score for one or two hands.

Statistical Analyses

Statistical analyses were performed with the SPSS (version 12). Descriptive statistics were used to describe the characteristics of the sample. To analyze change in different outcome measures between T0, T1, and T2, analysis of variance with a Bonferroni-Holm correction was applied.

RESULTS

Patient Characteristics

In total, 28 patients were referred to the study. Seventeen patients met the inclusion criteria (see Table 1). In total, 19 hands were treated. Patients who were excluded had irreversible joint contractures ($n = 6$), or other rheumatic diseases than RA ($n = 2$). Three patients did not want to participate. During the study, one patient dropped out because of pneumonia.

The results of the hands treated are presented in Table 2. Dexterity, measured by the SODA, improved significantly over time. In addition, the pain score of the SODA improved significantly over time. No significant changes were found on the grip strength, pinch strength, active ROM, DASH, and the MHQ. Although the DASH showed no significant differences, there is a tendency toward improvement.

TABLE 1. Patient Characteristics

Age [mean (SD), range]	56.5 (9.9) 35–74
Years of rheumatoid arthritis [mean (SD), range]	17.6 (10.7) 5–35
	% (n)
Female	53% (9)
Hand surgery in past	12% (2)
Wrist surgery in past	6% (1)
Hand dominance	
Right side	88% (15)
Left side	—
Both	12% (2)
Treated hand	
Right	59% (10)
Left	29% (5)
Both	12% (2)

DISCUSSION

The aim of this study was to explore and evaluate the effects of a treatment consisting of a MP-blocking splint combined with an exercise program in patients with RA and an intrinsic posture and pattern of movement of the hand. This posture is induced by domination of intrinsic hand muscles over extrinsic hand muscles, resulting in a changed pattern of movement of the hand. Our hypothesis was that the described intervention could restore normal movement patterns in patients who had reversible hand problems. And, in addition, regain the lost functional abilities of the hand and prevent or postpone deterioration of functions indefinitely.

In the current study, we found that the hands treated improved significantly over time on the total SODA score and the pain score of the SODA, indicating that dexterity and bimanual use of the hands increased after application of our therapy.

During this study, clients reported improvements in writing, playing the guitar, closing buttons, tie up shoelaces, and typing, but also revealed more control over their hands and better participation in their work. Despite of these clinical reports, no significant changes were found on grip strength, pinch strength, active ROM, DASH, and MHQ.

Reasons for the lack of significant changes could be the small sample size, and the variation in age and duration of RA. The calculated sample size could not be met due to lack of time and money. For the calculation of the sample size, we used the standard deviation of improvements on the MHQ. These data were provided by the developers of the MHQ from unpublished data. If we use the standard deviation of improvements of the current study, we find a considerably larger sample size than was calculated before the study. The improvement assessed by means of the MHQ between T0 and T2 (paired t-test) was 1.7 (SD: 13.9). If we use these figures to calculate the sample size ($\alpha = 5\%$,

TABLE 2. Means and Standard Deviation of the Outcome Measures of the Hands Treated

	T0	T1	T2	
	Mean (SD)	Mean (SD)	Mean (SD)	p- Value
Grip strength (kg)	16.2 (9.3)	19.0 (9.7)	19.1 (12.1)	0.632
Pinch strength (kg)				
Lateral pinch	5.0 (2.4)	5.8 (2.4)	5.6 (2.3)	0.531
Two-point pinch	2.4 (1.2)	3.1 (1.5)	3.1 (1.2)	0.150
Three-point pinch	3.4 (1.6)	4.0 (1.7)	4.2 (2.0)	0.451
Range of motion in degrees: TAM				
Dig II	141.7 (36.8)	142.2 (36.4)	142.6 (33.0)	0.997
Dig III	137.9 (39.3)	138.0 (41.6)	149.6 (32.8)	0.573
Dig IV	131.0 (44.1)	138.9 (48.4)	145.0 (35.9)	0.615
Dig V	139.2 (44.4)	144.7 (47.5)	153.3 (31.1)	0.587
Range of motion in degrees				
Dig II	70.8 (16.1)	72.7 (18.3)	73.8 (15.4)	0.859
Strickland Dig III	69.9 (20.1)	70.4 (22.2)	76.4 (15.6)	0.543
Dig IV	66.9 (20.1)	70.1 (23.5)	73.4 (15.7)	0.613
Dig V	71.5 (20.4)	74.5 (22.6)	79.8 (13.6)	0.422
SODA				
Total	88.2 (17.3)	96.9 (9.0)	97.5 (9.0)	0.046*
Pain	2.7 (3.1)	2.2 (2.1)	0.8 (1.3)	0.043*
MHQ				
Treated hand	54.0 (8.8)	58.0 (8.5)	55.7 (11.5)	0.452
DASH	37.0 (14.1)	28.3 (12.3)	29.3 (13.5)	0.105

T0 = pretreatment, T1 = posttreatment, and T2 = follow-up after three months.

TAM = total active motion of MP, PIP, and DIP joints; Strickland = total active range of motion of PIP and DIP joints; SODA = Sequential Occupational Dexterity Assessment*; MHQ = Michigan Hand Outcomes Questionnaire; DASH = Disability of the Arm, Shoulder, and Hand; p-values are the result of analysis of variance.

$\beta = 80\%$), about 529 patients would be needed to detect a significant change. We chose the MHQ, because we expected patients to experience improvement on several scales of the MHQ; overall hand function, activities of daily living, work performance, and patient satisfaction with hand function. The MHQ is found to be valid and reliable to assess hand disablement in RA patients and allows calculation of the outcome for one hand.²¹ If we had used the DASH score (mean improvement: 7.7, SD 19.1) for sample size calculation, 50 patients would have been sufficient to detect a significant change.

Lack of significant results also raises the question whether the outcome measures used are adequate and sensitive for change in this group of RA patients with an intrinsic-plus posture. No specific instruments are available to evaluate such a movement pattern. The SODA, measuring dexterity, approximates this outcome best. Unfortunately, the SODA measures the dexterity of both hands.

Additionally, it is uncertain whether the set of outcome measures fits the components necessary for an adequate movement pattern, such as grip strength

and joint mobility. It is interesting to define the contributions of the central nervous system (motor program), the peripheral nervous system, tendons, joints, and ligaments on the movement pattern of hands of RA patients and describe the effect of RA on the motor program and the structures mentioned. In this way, outcome measures that are more specific could be chosen and, if not available, possibly should be developed.

In the current study, it is assumed that an abnormal balance between the intrinsic and extrinsic muscles existed. We did not actually measure this, though surface electromyography or the Rotterdam Intrinsic Hand Myometer²⁹ might have been useful to substantiate such an imbalance.

The MHQ and the DASH were used to measure the patient's perceptions of their disabilities. No significant changes on both the MHQ and the DASH were found over time, although patients claimed a better motor control over the hand. In the literature, both instruments are said to be valid and reliable for patients with RA, but no specific information is available on the sensitivity to measure changes over time of these instruments.^{21,24,25}

It was interesting that there were also improvements in the untreated hands (data not shown). Most patients performed the exercises for both their hands, although not according to the instructions. It is not clear if the intervention or just the extra attention for function of the hand in general was responsible for these changes. In research, this posture is called the "carry-across effect."³⁰ In future research on rheumatoid hands, carry-across effects should be taken into consideration.

Looking at the intervention provided in the current study, it is clear that this intervention not only consists of supportive splint therapy and exercises, but also of patient education and instructions on activities of daily living (ADLs). A limitation of this study is the lack of control on patient compliance, the standardization of patient education, and the instructions on ADL. In future research, assessment of patient education should be performed and instructions to the patients should be standardized better.

CONCLUSION

In this descriptive pilot study, an innovative intervention, consisting of a MP-blocking splint combined with exercises, shows improvement of the dexterity of RA patients with an intrinsic-plus posture and a changed pattern of movement of the hands. This intervention seems to be a promising therapy. Because of the small sample size, the clinical nature, and lack of control, further research is needed to support these findings.

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- #1. The patient/subject population in the study all had
 - a. arthritis, some RA and some OA
 - b. RA and were female
 - c. RA and some had previous surgery
 - d. RA and none had previous surgery
- #2. A significant improvement was found in the following measure
 - a. SODA
 - b. DASH
 - c. ROM
 - d. MHQ
- #3. To demonstrate statistical significance the following was employed

- a. ICC
 - b. student T Test
 - c. standard deviation
 - d. ANOVA
- #4. The primary characteristic of the splint was that it
 - a. controlled ulnar drift
 - b. shifted motor function toward the FDS
 - c. blocked MP flexion
 - d. prevented EDC fatigue
 - #5. The results are definitive evidence that the method described is effective in enhancing dexterity in the RA population
 - a. true
 - b. false

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